EXPERT DECISION SYSTEM

FOR

LOCATION DETERMINATION OF INDUSTRIAL PARKS

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FIRST: INTRODUCTION

Based on fixed regional policy made by governments and business associations, business enterprises find themselves forced to choose between plots within a predetermined site instead of choosing a site within a region to be distinguished for industrial uses. Their traditional role in making their own market studies regarding inputs[1] and outputs[2] is no longer valid under the new circumstances. The central planner has taken over their role and given them limited paths along which they can practice their production. Site selection has turned into plot selection within a predetermined site.

This paper observes the relationship between the architectural product and its effect on the urban fabric in regions and provinces by means of scientific modeling. The topic of Industrial Parks (IPs), as being one of the most important elements needed to accommodate production units, can offer an interesting theme to illustrate the interaction between the built environment and the population. The developed methods for the clarification of the relationship between the IPs and urban localities in Jordan can by used to determine similar cases elsewhere.

SECOND: ECONOMIC ACTIVITIES

The state, as a representative of both public and private sectors, carries the responsibility of planning through public investment in physical and human capital. Allocating financial capital in order to provide the physical capital stock, such as buildings and public infrastructure (transportation network; electrical and communication networks etc.), can be considered as public interventions to steer the country development in compliance with the public strategy. Furthermore, public decision-makers have a big influence on allocating

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changes.

Economic activities can be divided into:

- Land-based activities;
- Administratively forced activities.

Kaldor[3] differentiates between two kinds of land- - -

-loose activities, the sources of materials needed for production are not top priorities, e.g. the case of the electronics industry. Foot-bound activities, such as agriculture and mining, make their investments close to where raw materials are available.

The establishment of public or private investments passes through almost the same process. Investors think in four parallel lines of thought when they intend to establish their own business line, and these are:

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1 Inputs are: natural resources; working force; suppliers of goods and services, and accessibility to information and innovations [1].

2 Output: Market access variegates strongly according to locations [1].

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- What is to be established?
- Why is it to be established?
- Where is it to be established?
- How is it to be established?

In this paper, we are going to focus on the third raised ques *Where is it to be* by using a mathematical approach of scientific analysis that can reflect the discussed dilemma in numbers.

THIRD: LOCATION OF ECONOMIC ACTIVITIES

The location will be used in association with physical subsistence such as the location of trees, buildings, plants etc. This location can be given by nature or initiated by humans who manipulate, restructure and create spatial location. In addition, location is always connected to distance because of the mobility people require to move from one location to another. One of the most important elements of human knowledge is the awareness of the necessity to have different spaces for different uses. With the accumulation of human knowledge over the years, a clear dividing line between workplace and residential space has been developed, where the separating distance has to be overcome constantly.

Location-appropriateness of IPs should not only be assessed according to the numerical results given by the science of modeling, but must also be subjected to other evaluation [4]:

- Distance to agglomeration areas in the country and province centers;
- Close connection to main road network;
- Reasonable distance to airports in the country;
- Direct connection to the railway network;
- Appropriate orientation regarding the prevailing wind direction;
- Within moderate climate area;
- Nearness to the existing infrastructure;
- Possibility for future extension;
- Far from agricultural areas;
- Far from underground water resources in the case of polluting industries;
- In harmony with political and social priorities;
- Within development area that provides encouraging tax-exemption.

FOURTH: LOCATION ANALYSIS AND MODELING TO LOCATE INDUSTRIAL PARKS

There are several ways to approach location analysis, such as:

1. The neo-
2. Concept of behavior;
3. Structural concept.

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[4] Not listed in a specific order.

The neo-
maximum profits, which guarantees obtaining the biggest difference between cost and revenues.

In contrast to the normative approach, the concept of behavior investigates the actual operation of enterprises and their performance in reality.

Representatives of the structural concept assume, through their structural concept, that
world economy traverse phases in which certain circumstances and production concepts are

location conditions are not endowed
- and reproduction processes, so that they are the result of social processes[5].

In this paper, the third method is going to be examined in detail by constructing a model that can be used as an Expert Decision System (EDS) that can reflect the relationship between Labor Force (LF) and the location of IPs in many ways as will be apparent hereafter.

FIFTH: MODELING

Modeling is a technique used in regional planning, which allows the demonstration of certain IP-related relations in a numerical form. The science of mathematics is widely used in this technique because of its ability to set relations in a logical relationship that can clarify the dilemma under discussion and reflect results in numerical form.

In this paper, a new model for the evaluation of big-scale projects, such as IPs, which was developed in the author s dissertation at the Graz University of Technology, is going to be presented. This modeling technique was called the Ranking Model (RM). As it will be apparent, the constructed RM gives no solutions for existing regional planning disparities, but rather points to possible solutions according to the strategies followed in each country.

5.1 THE RANKING MODEL

The RM[6] establishes an Algorithm[7] between groups of variables in the form of inputs and facilitates the deduction of outputs, which can be used for further analysis and conclusions. It allows the entering of measured or assumed values in order to observe the impact of these inclusions on the model outputs. For further satisfaction, the model offered a visual display chart, which incorporates the model results in a visual display facility.

5.1.1 RANKING MODEL STRUCTURE

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[5] Due to the momentousness of this declarative paragraph by , the original German text shall be cited as following:
gegeben sind, sondern dass sie im gesellschaftlichen Produktions- und Reproduktionsprozess produziert

[6] The Ranking Model was developed by the author in his dissertation entitled
Urban and Regional Development, a case study of Jordan

[7] *thm (pronounced AL-go-rith-um) is a procedure or formula for solving a problem. The word derives from the name of the mathematician, Mohammed Ibn-Musa Al-Khowarizmi, who was part of the royal court in Baghdad and who lived from about 780 to 850 AD* [5].

Plate 1 shows the logical setup of the RM as follows:

1. The case-study country;
2. The administrative divisions in Jordan divided into three regions, where each one is divided into four provinces;
3. Each province will be listed in a separate plate (e.g. Plate 2) in order to show the following parameters:
   - The number of population according the latest population census made in 1994 listed for age groups (< 1- 80 +);
   - Average Growth Rate of the Population (AGRP) for the year 2002;
   - The total population according to the latest population census made in 1994;
   - The total population according to the population projections for 2002;
   - Population at Productive Age (PPA) as a result of the calculation of P2002 for the age groups 15-64;
   - The number of the LF after the deduction of a percentage of the not willing to work LF, which was estimated by the author at 5%;
   - Estimated Industrial Labor Force (EILF) as a result of the multiplication of the calculated number of LF with an estimated share of industrial labor force out of the LF. These estimations are based on the a
     province to another (7-13) %;
   - Estimated Employed Industrial Labor Force (EEILF) after deducting a percentage of unemployment estimated at 15% as an average value for all Jordanian provinces;
   - Planned Industrial Labor Force (PILF) as a result of the multiplication of PPA 2002 with the share of the PILF out of the PPA[8].
   - Planned Additional Industrial Labor Force (PAILF) as a result of PILF- EEILF.
4. Plate 3 present one of the 17 discussed existing and planned industrial parks in Jordan and present the three ranking model elements, which are:
   - Inputs;
   - Outputs;
   - Graphical display chart.

5.1.1.1 RANKING MODEL INPUTS

Model inputs are[9]:

1.1 IP data:

- Design area;
- Existing area;
- Employed Labor Force in the Existing Industrial Park (ELFEIP);
- Employable Labor Force in the Planned Industrial Park (ELFPIP)[10];

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[8] This share equals 20%, which represents the new planned value for the share of industrial worker out of the total LF. The empirically measured value equals 13%.

[9] The followed numbering for inputs, outputs and display chart in plate 3 is as following:
1. Inputs, which include the sub-numbers 1.1-1.9;
2. Outputs, which include the sub-numbers 2.1-2.6;
3. Display chart.

[10] In the case of existing industrial parks, data about the ELFEIP can be obtained from the industrial park operators. However, in the case of planned industrial parks, estimations can be used to indicate the ELFPIP.

1.2 Average Growth Rate of the Population;
1.3 Estimated Employed Industrial Labor Force share of the total Population (EEILF/P);
1.4 Planned Industrial Labor Force share of the total Population (PILF/P);
1.5 Population at Productive Age (PPA);
1.6 Localities in the province including a population of 5,000 and more;
1.7 Population projection made for each locality for the year 2002 as described before;
1.8 Distance (D) between the locality and the discussed industrial park in km[11]. In our case, the distance was measured between existing or planned IPs and each location, which comes into question[12].
1.9 Mathematical function of the gravitation model:

$$INT_{ij} = g * A_i * A_j * d_{ij}^{-\alpha}$$

Where:

INTij:	Interaction (exchange relationship between the location i and location j;
g :	gravitation constante
A_i:	Number (attractiveness of i)
A_j:	Number (attractiveness of j)
d_{ij}:	Distance between the locations i and j
α:	Parameter of distance mobility

5.1.1.2 RANKING MODEL OUTPUTS

The following outputs are expected to result from the constructed RM:

1. Estimated Employed Industrial Labor Force (EEILF) for each locality:

$$EEILF = \frac{P\ 2002 * EEILF/P}{100}$$

The availability of feasibility studies for such projects can and should give the estimations much more credibility and greater accuracy.

[11] The Distance (D) between production sites and the agglomeration spots has to be overcome by the LF almost daily. Attractiveness or non-
most of the cases, which controls Labor Force Potential of the Industrial Park (LFPIP). For example, changing the D variable, which increases the attractiveness of an IP, can choose the optimal location of a proposed IP. As it is apparent in the GM equation used, the D factor is fundamental and crucial. Therefore, changing the distance between the agglomeration spots and the IP should affect the RM outputs. So we can encourage the mobility of PILF towards the less inhabited regions, or the forwarding of IPs towards the agglomeration spots. Finding the optimal D factor can be achieved by using the suggested EDS without neglecting other output elements.

[12] Measuring the distance was taken on National Soil Map and Land Use Project (NSMLUP) maps scale 1:50,000 and was compared to Royal Geographic Center (RJC) maps and according to related IP figures. Furthermore, personal site visits by car were recorded for comparison.

2. Planned Industrial Labor Force (PILF) for each locality:

$$PILF= \frac{P\ 2002 * PILF/P}{100}$$

3. Planned Additional Industrial Labor Force (PAILF) for each locality:

$$PAILF= PILF - EEILF$$

4. Planned Industrial Labor Supply for the Industrial Park (PILSIP) calculated for each locality according to the gravitation model formula mentioned above;
5. Residual Planned Industrial Labor Supply (RPILS) calculated for the whole province:

$$RPILS= SUM\ (PILSIP) - ELFEIP$$

6. Employment ratio presented in percentage=

$$\frac{\text{ELFEIP (by existing IP) or ELFPIP (by planned IP)}}{\text{PILSIP}}$$

7. Residual Labor Supply Ratio (RLSR) calculated for the whole province, which present the needed number similar to the discussed IP:

$$RLSR= \frac{RPILS}{ELFEIP\ (ELFPIP)} * 100\ \%$$

The main model variable, which is RPILS can be anteceded by a negative (+) or positive (-) sign, which indicates:

Positive (+) sign	**Meaning**	Surplus in RPILS
Negative (-) sign	**Meaning**	Shortage in RPILS

The positive (+) sign preceding the RPILS indicates the over abundance (available PILF that cannot be employed in the discussed IP). On the contrary, the negative (-) sign indicates that there is a shortage in the PILF that can be employed in the discussed IP but is not available.

5.1.1.3 Ranking Model Display Chart

In order to facilitate the understanding of the model results, graphical display charts have been used to demonstrate the relationship between the followings[13]:

- Planned Industrial Labor Force (PILF) for each locality;
- Planned Additional Industrial Labor Force (PAILF) for each locality;
- Planned Industrial Labor Supply for the Industrial Park (PIILSIP) for each locality;
- Distance (D) between the localities and the discussed IP.

The charts demonstrate the outputs PILF, PAILF and PILSIP as columns for each locality, which are to be read on the primary Y axis and the input variable D is presented as line-square and can be read on the secondary Y axis.

[13] See Plate 3.

5.2 Model Flexibility

The developed RM acts not only as an assessment tool for existing and planned IPs, it is also flexible and possesses a high grade of adaptability. Model flexibility is guaranteed by its ability to accept new values in the input field, which can be summarized in the Table 1.

An example of the RM flexibility can be demonstrated on the existing Al Hussein Ibn Abdulla II Industrial Estate (AHIAIE) at Karak, see plate 3. The increase in the Employed Labor Force in the Existing Industrial Park (ELFEIP) from 2,000 up to 2,388 should guarantee the employment of the Residual Planned Industrial Labor in this province, which is expressed in the model in RPILS and equals in this case the shown surplus of 388. Therefore, the number of IPs needed for this province will be zero, which means that there is no need to plan an extra industrial park, because the RPILS can be absorbed by the existing IP by means of increasing the ELFEIP.

5.4 Model Merit

Table 1 summarizes the competence of this model as a means of analysis that is needed by architects, regional planners and policy makers. It is fairly obvious that this model has its strengths, which can be summarized as follows:

1. Computerized interface[14];
2. Applicability for the use of various projects such as IPs, schools, hospitals and water projects etc.;
3. The model can act as an Expert Decision System;
4. Establishing a data base on each evaluated project;
5. Flexibility allowing modification in input field;
6. Extendibility by including new factors such as market analysis;
7. Means of identifying urban and regional development tendencies;
8. Identifying the optimal project location;
9. Indicating regional disparities;
10. Serving training programs in various economic fields as needed.

But this model also has its weaknesses, which can be summarized as follows:

1. Model dependency on national census and projections;
2. Difficulty in specifying the distance between localities and IPs (preferable when accrued electronically by using digital maps);
3. Model depends on administrative divisions in the country instead of the location and population of urban localities;
4. The model calculates the RPILS for the whole province instead of for each locality;
5. Interlocking between the catchment area of each industrial park, which affects the PILSIP.

The above-mentioned model weaknesses can be overcome by conducting a new research subject, which can facilitate the measurement of the distance between the localities and the IPs digitally. This system must link numerical data provided by the Department of Statistics with geographic digital maps (GIS-maps) in order to establish a platform by which distances can be measured on a screen and automatically linked with the input variables.

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[14] Microsoft Excel program can act as a proper computer program, which can ease entering and modifying the input elements and display the results in chart form.

TABLE 1
RANKING MODEL FLEXIBILITY

Model Inputs	Measure	Model Outputs	Impact on Urban and Regional Fabric
1. IP-data	Enlarging or reducing the size of the Industrial Park (IP)	No output relation	▪ Enlarging or reducing the industrial park area and its presence in the urban and regional fabric. ▪ More or less traffic and infrastructure.
	Increasing or decreasing the employed or employable industrial labor force ELFEIP or ELFPIP	Shortage or surplus in the Residual Planned Industrial Labor Supply (RPILS)	▪ Increasing or decreasing the industrial park attractiveness. ▪ Attractive or repulsive region.
2. Average Growth Rate of the Population (AGRP)	Decreasing or increasing the AGRP	Decreasing or increasing Population (P)	▪ Decreasing or increasing the size and density of urban fabric
3. Estimated Employed Industrial Labor Force share of the total population (EEILF/P)	Decreasing or increasing the EEILF	Decreasing or increasing the population and thereupon the EEILF, PILF, PAILF, PILSIP, RPILS and RLSR	▪ Increase or decrease in agglomeration nearby the IPs; ▪ More or less traffic, ▪ More or less Infrastructure, ▪ More or less services.
4. Planned Industrial Labor Force share of the total population (PILF/P)	Decreasing or increasing the PILF	Decreasing or increasing the PILF, PAILF, PILSIP, RPILS and RLSR	
5. Population at Productive Age (PPA)	Decreasing or increasing the PPA	Decreasing or increasing the population and thereupon the EEILF, PILF, PAILF, PILSIP, RPILS and RLSR	
6. Localities	Increasing or decreasing the number urban and rural localities	Decreasing or increasing the Distance (D) between the localities and IPs	▪ Dense or loose urban fabric. ▪ More or less agglomeration spots. ▪ Affecting the development direction.
7. Population (P)	Changing the number of population in the various urban localities	Decreasing or increasing the population and thereupon the EEILF, PILF, PAILF, PILSIP, RPILS and RLSR	▪ Increasing or decreasing the size and density of agglomeration spots.
8. Distance (D)	Changing the distance between the location of residency and workplace	Decreasing or increasing the PILSIP, RPILS and RLSR	▪ Extravagant changes in urban and regional fabric.
9. Mathematical Function	Using other mathematical formulas and parameters	Changing the model sensitivity and results	▪ Implementation of other urban and regional policy accordingly.

AGRP:	Average Growth Rate of the Population	P:	Population
D:	Distance	PAILF:	Planned Additional Industrial Labor Force
EEILF:	Estimated Employed Industrial Labor Force	PILF:	Planned Industrial Labor Force
EEILF/P:	Estimated Employed Industrial Labor Force share of the total Population	PILF/P	Planned Industrial Labor Force share of the total P
		PILSIP:	Planned Industrial Labor Supply for the IP
ELFEIP:	Employed Labor Force in the Existing IP	PPA:	Population at Productive Age
ELFPIP:	Employable Labor Force in the Planned IP	RLSR:	Residual Labor Supply Ratio
IP:	Industrial Park	RPILS:	Residual Planned Industrial Labor Supply

Source: Author [3].

The RM calculates the RPILS as a result of SUM (PILSIP) ELFEIP in the case of existing parks (or ELFPIP in the case of planned parks) for the whole province. For more model accuracy, the RPILS can be calculated for each locality by adding a new column to the ranking model next to 2.4 PILSIP. In that case, the user of the model can have the number of ed Industrial Labor Supply for Locality (RPILSL).

It is fairly obvious that the ranking model can be used as an expert decision system for urban and regional planners, architects, private investors and public authorities and therefore it has achieved the goals of its development.

5.5 RANKING MODEL SUMMARY

Plate 4 present 17 industrial parks in Jordan where seven of them exist and 10 are planned.

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